PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing: 01 March 2001 (01.03.01)	
International application No.: PCT/NL00/00586	Applicant's or agent's file reference: P49296PC10
International filing date: 24 August 2000 (24.08.00)	Priority date: 24 August 1999 (24.08.99)
Applicant: FEENSTRA, Frits, Kornelis	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International preliminary Examining Authority on:

12 January 2001 (12.01.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer:

J. Zahra

Telephone No.: (41-22) 338.83.38

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

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PCT/NL 0 0 / 0 0 5 8 6
International Application No.

24 AUG 2000 (24.08.00)
International Filing Date

BUREAU VOOR DE INDUSTRIËLE EIGENDOM
P.C.T. INTERNATIONAL APPLICATION
Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum) P49296PC10

Box No. I TITLE OF INVENTION

Method for making a dental element

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

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☐ This person is also inventor.

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Facsimile No.

Teleprinter No.

State *(that is, country)* of nationality: NL

State *(that is, country)* of residence: NL

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

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This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is,country)* of nationality: NL

State *(that is, country)* of residence: NL

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

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☐ **Adress for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

RO/NL

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- ☒ AP **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **MZ** Mozambique, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **TZ** United Republic of Tanzania, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ EA **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ EP **European Patent:** **AT** Austria, **BE** Belgium, **CH and LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ OA **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

- ☒ AE United Arab Emirates
- ☒ AG Antigua and Barbuda
- ☒ AL Albania
- ☒ AM Armenia
- ☒ AT Austria
- ☒ AU Australia
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- ☒ BA Bosnia and Herzegovina
- ☒ BB Barbados
- ☒ BG Bulgaria
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- ☒ KG Kyrgyzstan
- ☒ KP Democratic People's Republic of Korea
- ☒ KR Republic of Korea
- ☒ KZ Kazakhstan
- ☒ LC Saint Lucia
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- ☒ LT Lithuania
- ☒ LU Luxembourg
- ☒ LV Latvia
- ☒ MA Morocco
- ☒ MD Republic of Moldova
- ☒ MG Madagascar
- ☒ MK The former Yugoslav Republic of Macedonia
- ☒ MN Mongolia
- ☒ MW Malawi
- ☒ MX Mexico
- ☒ MZ Mozambique
- ☒ NO Norway
- ☒ NZ New Zealand
- ☒ PL Poland
- ☒ PT Portugal
- ☒ RO Romania
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- ☒ SI Slovenia
- ☒ SK Slovakia
- ☒ SL Sierra Leone
- ☒ TJ Tajikistan
- ☒ TM Turkmenistan
- ☒ TR Turkey
- ☒ TT Trinidad and Tobago
- ☒ TZ United Republic of Tanzania
- ☒ UA Ukraine
- ☒ UG Uganda
- ☒ US United States of America
- ☒ UZ Uzbekistan
- ☒ VN Viet Nam
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- ☒ ZW Zimbabwe

Check-box reserved for designating States which have become party to the PCT after issuance of this sheet:

☐

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) 24 August 1999 (24.08.99) (24.08.99)	1012897	NL		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s) 1

* *Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):* ISA / EP

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date (day/month/year)	Number	Country (or regional Office)
3 May 2000	SN 33945 NL	NL

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets**:

request	: 3
description (excluding sequence listing part)	: 9
claims	: 2
abstract	: 1
drawings	:
sequence listing part of description	:
Total number of sheets	: 15

This international application is **accompanied by** the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological materia
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☐ other *(specify)*:

Figure of the drawings which should accompany the abstract:

Language of filing of the international application: English

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

M. J. Hatzmann

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1. Date of actual receipt of the purported international application: 24 AUG 2000 (24.08.00)
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA /
6. ☐ Transmittal of search copy delayed until search fee is paid.

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Date of receipt of the record copy by the International Bureau: 18 SEPTEMBER 2000 (18.09.00)

Titel: Werkwijze voor het maken van een tandheelkundig element

De uitvinding heeft betrekking op een werkwijze voor het maken van een functioneel tandheelkundig element en op een tandheelkundig element dat verkregen kan worden middels genoemde werkwijze.

Tandheelkundige elementen, zoals kronen, worden in de klinische praktijk voornamelijk toegepast voor het vervangen of corrigeren van tandstructuren. Het kan hierbij gaan om geheel of gedeeltelijk verloren gegane tanden of kiezen. Tot op heden werden materialen voor dergelijke elementen met name onderzocht op technologische/fysische en chemische eigenschappen. Tegenwoordig speelt daarnaast het biologische aspect een groeiende rol.

Tandheelkundige elementen kunnen worden vervaardigd van verschillende materialen. Voorbeelden hiervan zijn polymeren, metalen, composieten, combinaties van porselein en metaal, porselein en andere keramische materialen. Glazen en keramische materialen vormen een ideale groep van materialen voor tandheelkundige elementen, omdat ze hard zijn, een hoge slijtweerstand hebben, chemisch inert zijn in veel milieus (biocompatibiliteit), en eenvoudig kunnen worden gevormd tot een esthetisch tandheelkundig element. Een brede toepassing van deze materialen wordt echter tegengewerkt door de inherente brosheid die dikwijls het gevolg is van beperkingen in het productieproces en van de materiaalkeuze. Recente ontwikkelingen hebben tot verschillende keramische systemen geleid, zoals gesinterde keramiek, met glas geïnfiltreerd keramiek en glas-keramiek van uiteenlopende samenstellingen, die minder bros zijn.

De vervaardiging van tandheelkundige elementen is in de praktijk een ingewikkelde en tijdrovende aangelegenheid. Het gaat om producten die op individuele basis worden vervaardigd, omdat de precieze vorm van het element immers voor elke tand of kies in ieder individu anders is. Conventionele technieken die zijn toegepast, maken veelal

gebruik van een mal. Aangezien deze doorgaans slechts eenmalig gebruikt kan worden, zal duidelijk zijn dat deze technieken zeer kostbaar zijn.

In het verleden zijn wel technieken voorgesteld waarmee het mogelijk zou zijn om het vervaardigingsproces van tandheelkundige elementen te vereenvoudigen. Zo is door Abe et al., in Int. J. Japan Soc. Prec. Eng., vol. 30, no. 3, 1996, blz. 278-279, voorgesteld een selectieve laser-sintering (SLS) uit te voeren met titanium. Bij deze techniek treedt echter vaak krimp op. Ook kunnen er micro-cracks ontstaan, hetgeen de techniek ongeschikt maakt voor vervaardiging van functionele tandheelkundige elementen. In de Europese octrooiaanvrage 0 311 214 is voorgesteld om een kroon te maken met behulp van frezen. Frezen biedt niet de mogelijkheid om gekleurde elementen te maken. Bovendien is de keuze voor geschikte materialen die door frezen kunnen worden bewerkt beperkt. Zoals gezegd, vormen keramische materialen een ideale groep materialen voor het vervaardigen van tandheelkundige elementen, omdat ze hard, zeer slijtvast en onder veel omstandigheden inert zijn.

Het Amerikaanse octrooischrift 5.690.490 beschrijft een methode voor het vervaardigen van een pasmodel voor een tandheelkundig element door zgn. 'pinhead molding'. De methode behelst het gebruik van een soort matrixprint-techniek, waarbij materiaal wordt opgespoten. De printer wordt aangestuurd met een CAD/CAM programma. De gegevens waar dit programma gebruik van maakt, zijn verkregen uit een laserscan van de tand of de kies die moet worden vervangen.

In het Amerikaanse octrooischrift 5.823.778 wordt een werkwijze beschreven voor het vervaardigen van een tandheelkundig element waarbij een indruk van het gebit van een patiënt wordt verkregen, die vervolgens als mal wordt gebruikt om een gebitselement na te maken. Dit element wordt in laagjes afgebroken en elk laagje wordt gescand om

drie dimensionaal computermodel van het gebitselement te verkrijgen.

De onderhavige uitvinding beoogt een techniek te verschaffen waarmee functionele tandheelkundige elementen op een flexibele en efficiënte wijze kunnen worden vervaardigd. Voorts wordt beoogd dat de techniek geen gebruik maakt van een mal en dat het mogelijk is om tandheelkundige elementen van polymeer, metaal of keramisch materiaal, of van combinaties daarvan te maken.

Verrassenderwijs is thans gevonden dat de gestelde doelen worden bereikt door een functioneel tandheelkundig element te vervaardigen onder toepassing van een driedimensionale druktechniek.

Driedimensionale druktechnieken zijn op zich bekend. Deze zijn onder meer beschreven in de Europese octrooiaanvrage 0 431 924, het Amerikaanse octrooischrift 5.902.441 en de internationale octrooiaanvragen 94/19112, 97/26302 en 98/51747. Voor een beschrijving van de details van de techniek wordt verwezen naar de genoemde documenten, welke dan ook als hierin ingelast beschouwd dienen te worden.

De werkwijze volgens de uitvinding is in beginsel geschikt om alle typen tandheelkundige elementen te vervaardigen. Voorbeelden hiervan zijn kronen, (voor- en zijtanden), inlays, overlays, onlays, deelkronen, fixaties en veneers.

Bij voorkeur wordt bij een patiënt, waarbij een tandheelkundig element vervangen/geplaatst dient te worden, eerst nauwkeurig opgemeten welke vorm het element moet hebben. Hierbij zal, indien mogelijk, dikwijls worden uitgegaan van de vorm van de tand of kies, of het gedeelte daarvan, dat aan vervanging toe is. Het heeft de voorkeur dat het opmeten kan plaatsvinden op een wijze die de patiënt zo min mogelijk ongemak bezorgt. Bijzonder geschikte technieken voor het opmeten van de vorm voor het tandheelkundige element maken gebruik van optische

scantechnieken, in het bijzonder van lasers. Hierbij worden in elektronische vorm gegevens verkregen over de gewenste vorm en afmetingen, die direct gevisualiseerd kunnen worden in een computer. De elektronische gegevens over de vorm en afmetingen van het tandheelkundige element worden bij voorkeur door een computer aangewend om de uitvoering van de driedimensionale druktechniek aan te sturen. Een andere geschikte methode voor het opmeten is volgens de CEREC-techniek, Sirona Dental Systems GmbH, Bensheim, Duitsland.

In de driedimensionale druktechniek wordt een geschikt materiaal achtereenvolgens in laagjes aangebracht, waarbij specifieke stappen worden genomen om ervoor te zorgen dat elk laagje slechts op bepaalde gewenste plaatsen hecht op het voorafgaande laagje. Deze specifieke stappen worden bepaald door de gewenste vorm van het tandheelkundige element en bij voorkeur aangestuurd door bovengenoemde elektronische gegevens.

Volgens de uitvinding wordt bij genoemde specifieke stappen gebruik gemaakt van een selectieve uitharding. Het tandheelkundige element wordt opgebouwd uit laagjes, ditmaal van een specifiek uithardbaar materiaal, waarbij elk laagje hecht op de gewenste plaatsen van het voorafgaande laagje door het materiaal alleen op de gewenste plaatsen te laten uitharden. Het niet uitgeharde materiaal zal niet hechten op het voorafgaande laagje en kan eenvoudig verwijderd worden.

Het uithardbaar materiaal is bij voorkeur een nanomeer materiaal, als beschreven in WO-A-98/51747. Een dergelijk materiaal bestaat uit nanomere, anorganische vaste stofdeeltjes met polymeriseerbare en/of polycondenseerbare, organische groepen aan hun oppervlak. Het heeft de voorkeur dat dit materiaal wordt aangebracht in de vorm van een vloeibare massa, bijvoorbeeld een dispersie van het materiaal in water, een organisch oplosmiddel, of een monomeeroplossing. Onder een monomeeroplossing wordt in dit verband een mengsel van UV

fotopolymeriseerbare monomeren en een daarvoor geschikt oplosmiddel verstaan. Geschikte voorbeelden van monomeren bevatten epoxy- en/of acrylgroepen. Als oplosmiddel kan bijvoorbeeld styreen worden gebruikt. Onder nanomere, anorganische vaste stofdeeltjes worden deeltjes verstaan met een gemiddelde deeltjesgrootte (diameter) van minder dan 200 nm, bij voorkeur minder dan 100 nm. Bijzonder geschikt zijn deeltjes met een gemiddelde diameter van 5-50 nm gebleken.

De nanomere, anorganische vaste stofdeeltjes kunnen uit verschillende materialen bestaan, doch het heeft de voorkeur dat ze een metaal of metaalverbinding omvatten. Voorbeelden van geschikte materialen zijn onder meer ZnO, CdO, SiO_2, TiO_2, ZrO_2, CeO_2, SnO_2, Al_2O_3, In_2O_3, La_2O_3, Fe_2O_3, Cu_2O, Ta_2O_5, Nb_2O_5, V_2O_5, MoO_3, WO_3, CdS, ZnS, PbS, Ag_2S, GaSe, CdSe, ZnSe, ZnTe, CdTe, AgCl, AgBr, AgI, CuCl, CuBr, CdI_2, PbI_2, CdC_2, SiC, AlAs, GaAs, GeAs, InSb, BN, AlN, Si_3N_4, Ti_3N_4, GaP, InP, Zn_3P_2, Cd_3P_2, fosfaten, silicaten, zirkonaten, aluminaten, stannaten en overeenkomstige mengoxiden (zoals met een perowskitstructuur, bv. $BaTiO_3$ en $PbTiO_3$). De voorkeur gaat uit naar materialen die oxiden, sulfiden, seleniden of telluriden van metalen, of mengsels daarvan, omvatten. Nanomere deeltjes van SiO_2, TiO_2, ZrO_2, ZnO, Ta_2O_5, SnO_2 en Al_2O_3 (in alle vormen, in het bijzonder als böhmit, AlO(OH)) en mengsels daarvan hebben in het bijzonder de voorkeur.

De polymeriseerbare en/of polycondenseerbare, organische groepen kunnen bij voorkeur polymeren vormen onder invloed van bestraling met een laser. Deze polymerisatie kan via elk geschikt mechanisme verlopen. Bij voorkeur is de polymerisatie fotochemisch of thermisch. Desgewenst kan er aan de vloeibare massa, in welke vorm het nanomere materiaal wordt verwerkt, een initiator worden toegevoegd. (Meth)acryl-, allyl-, vinyl-, epoxy-, hydroxy-, carboxy- en aminogroepen hebben de voorkeur,

waarbij bijzondere voorkeur uitgaat naar (meth)acryl- en epoxygroepen.

Volgens de uitvinding heeft het de voorkeur dat de polymeriseerbare en/of polycondenseerbare, organische groepen een relatief laag molecuulgewicht hebben. Bij voorkeur ligt hun molecuulgewicht onder 500, bij bijzondere voorkeur onder 200.

De bereiding van nanomere, anorganische vaste stofdeeltjes met polymeriseerbare en/of polycondenseerbare, organische groepen aan hun oppervlak is op zich bekend en is onder meer beschreven in de internationale octrooiaanvrage 98/51747.

Zoals gezegd wordt het nanomere materiaal in de vorm van een vloeibare massa in laagjes aangebracht. De vloeibare massa kan worden gevormd door een dispersie van het nanomere materiaal in water of een ander geschikt oplosmiddel te vormen. Hierbij wordt bij voorkeur gewerkt met een concentratie tussen 25 en 60 gew.% nanomeer-materiaal, betrokken op het gewicht van de dispersie. Het aanbrengen van de laagjes kan op elke geschikte wijze, zoals sproeien, strijken en dergelijke, plaatsvinden. De dikte van de laagjes ligt in deze gevallen bij voorkeur tussen 0,01 en 0,1 mm.

Tussen het aanbrengen van de verschillende laagjes door wordt elk laagje uitgehard op specifieke, gewenste plaatsen. De elektronische gegevens die zijn verkregen door het opmeten van de vorm en afmetingen van het gewenste tandheelkundige element bij een patiënt kunnen worden gebruikt om een laser aan te sturen die nauwkeurig op de gewenste plaatsen elk laagje bestraalt zodat de gewenste uitharding optreedt en het laagje op de gewenste plaatsen aan een voorafgaand laagje hecht. Niet uitgehard materiaal kan eenvoudig worden verwijderd.

Deze methode kan als bijzonderheid tevens (met anorganische kleurstof) ingekleurde UV uithardende nanomeer houdende harsen verwerken waarme gekleurde functionele

tandheelkundige elementen vervaardigd kunnen worden. Ook biedt dit proces de mogelijkheid om met behulp van een UV lamp het oppervlak in een keer te belichten en daarmee uit te harden, hetgeen sneller verloopt dan lokaal uitharden met een laser. Het proces maakt gebruik van een aantal nozzles gelijk aan een macht van 2, bij voorkeur tussen de 100 en 10.000 nozzles, in het bijzonder 1536 nozzles. Volgens een alternatieve uitvoeringsvorm kan de vloeibare massa in laagjes worden aangebracht met behulp van een inkjetmethode. Bij voorkeur wordt hierbij gebruik gemaakt van een piëzo inkjet printer met een head van bij voorkeur 1536 nozzles. In dit geval is de dikte van de laagjes bij voorkeur tussen 10 en 40 μm.

In bepaalde gevallen is het van voordeel gebleken om het tandheelkundige element te onderwerpen aan een thermische nabehandeling, zodat een volledige uitharding wordt bereikt. Aldus wordt bij voorkeur het tandheelkundige element kortstondig verwarmd tot een temperatuur tussen 60 en 150°C, bij bijzondere voorkeur tussen 80 en 130°C.

In plaats daarvan, of in aanvulling daarop wordt bij voorkeur een thermische verdichting bewerkstelligd. Daartoe wordt het tandheelkundige element verwarmd tot een temperatuur van ten minste 250°C, bij voorkeur ten minste 400°C en nog liever ten minste 500°C. Deze behandeling draagt eraan bij dat het tandheelkundige element bijzonder gunstige eigenschappen krijgt.

Wanneer op één van de hierboven beschreven wijzen het tandheelkundige element is gevormd, kan het voorkomen dat dit nog enigszins bijgevormd moet worden. Zoals al is aangegeven is het een voordeel van de uitvinding dat zeer nauwkeurig gewerkt kan worden. Het bijvormen zal daarom minder omslachtig zijn dan bij de tot op heden toegepaste technieken. Wijzen waarop het bijvormen kan worden uitgevoerd zijn onder meer slijpen, vijlen, polijsten, schuren, stralen of behandelen met een kogelbed, afhankelijk van het gekozen materiaal van het

tandheelkundige element. Hierna is veelal een oppervlakte behandeling/sealing gewenst.

De uitvinding zal thans nader worden toegelicht aan de hand van de volgende voorbeelden.

Voorbeeld 1

ZrO_2-deeltjes met een gemiddelde diameter van 10 nm wordt onder roeren en ultrasoonbehandeling gedispergeerd in isopropanol. Ter modificatie van het oppervlak van de deeltjes wordt 3,2 gew.%, betrokken op het ZrO_2 gehalte, 3-methacryloxypropyltrimethoxysilaan (MPTS) toegevoegd. De dispersie wordt gedurende 3 uur bij 50°C geroerd ter verkrijging van een gesilaniseerd oppervlak.

Vervolgens wordt 3,2 gew.%, betrokken op het ZrO_2 gehalte, tetraethyleenglycoldimethacrylaat (TEGDMA) toegevoegd en wordt gedurende 15 minuten bij 20°C geroerd. Er wordt 3 mol% Irgacure® 184 toegevoegd per mol dubbele binding. Daarna wordt het oplosmiddel gedeeltelijk verwijderd onder vacuüm.

Van het aldus verkregen materiaal wordt de uithardingsdiepte (Cd) bepaald. Een hoeveelheid van het materiaal wordt in een cilindrische vorm gebracht, welke vorm UV-straling doorlaat. Een UV-droger met een vermogen van 400 mW/cm^2 wordt gebruikt voor het uitharden. Het materiaal wordt blootgesteld aan straling gedurende een periode tussen 1 en 2 minuten (tot 20 UV bestralingscycli). Hierbij wordt het gebruikte vermogen gevarieerd. De resultaten van deze tunneluithardingstest worden in een SLA-machine geprogrammeerd (SLA250 van de firma 3D Systems Inc., Valencia CA USA)

Van de bovenbeschreven dispersie wordt een laagje met een dikte van 0,05 mm op een bouwoppervlak (20x20 cm) aangebracht met behulp van een strijkmes. Dit laagje wordt selectief bestraald met een HeCd laser, zodat op specifieke plaatsen een uithardingsreactie wordt geïnitieerd. Deze procedure wordt herhaald totdat een element van de gewenste vorm en afmeting verkregen is.

Tot slot wordt het element gedurende 15 minuten blootgesteld aan een hittebehandeling bij 120°C.

CONCLUSIES

1. Werkwijze voor het vervaardigen van een functioneel tandheelkundig element, waarbij een driedimensionale druktechniek wordt toegepast.

2. Werkwijze volgens conclusie 1, waarbij de vorm en afmetingen van het tandheelkundige element worden opgemeten bij een patiënt onder toepassing van een optische scantechniek, bij voorkeur een lasertechniek.

3. Werkwijze volgens conclusie 2, waarbij de lasertechniek gegevens over vorm en afmetingen in elektronische vorm oplevert.

4. Werkwijze volgens één van de voorafgaande conclusies, waarbij laagjes van een geschikt materiaal achtereenvolgens op elkaar worden aangebracht, waarbij maatregelen worden getroffen zodanig dat elk laagje op gewenste plaatsen aan een voorafgaand laagje hecht en overtollig, niet-hechtend materiaal wordt verwijderd.

5. Werkwijze volgens conclusie 4, waarbij het geschikte materiaal een nanomeer materiaal is en waarbij de hechting tussen de laagjes wordt gerealiseerd door het nanomere materiaal uit te harden.

6. Werkwijze volgens conclusie 5, waarbij het nanomere materiaal bestaat uit nanomere, anorganische vaste stofdeeltjes met polymeriseerbare en/of polycondenseerbare, organische groepen aan hun oppervlak.

7. Werkwijze volgens conclusie 5 of 6, waarbij de laagjes worden aangebracht met behulp van een piëzo inkjet head.

8. Werkwijze volgens conclusie 7, waarbij wordt uitgehard met behulp van UV licht.

9. Werkwijze volgens conclusies 5-8, waarbij een computer wordt toegepast om, op basis van de gegevens verkregen bij het opmeten, een laser aan te sturen die het nanomere materiaal op specifieke, gewenste plaatsen uithardt door bestraling.

10. Werkwijze volgens conclusies 5-9, waarbij het tandheelkundige element wordt blootgesteld aan een thermische nabehandeling bij een temperatuur van 60 tot 150°C.

11. Werkwijze volgens conclusies 5-10, waarbij het tandheelkundige element thermisch wordt verdicht bij een temperatuur van ten minste 250°C.

12. Werkwijze volgens één van de voorafgaande conclusies, waarbij het tandheelkundige element wordt bijgevormd door te slijpen, vijlen, polijsten, schuren, stralen of behandelen met een kogelbed.

13. Tandheelkundig element verkrijgbaar middels een werkwijze volgens één van de voorafgaande conclusies.

UITTREKSEL

De onderhavige uitvinding heeft betrekking op een werkwijze voor het vervaardigen van een functioneel tandheelkundig element, zoals een kroon. Volgens de uitvinding wordt hierbij gebruik gemaakt van een driedimensionale druktechniek. De grote voordelen van de uitvinding zijn dat er geen mal meer nodig is, hetgeen een aanzienlijke kostenbesparing met zich meebrengt, dat een grote nauwkeurigheid bereikt wordt en dat het element van verschillende materialen kan worden gemaakt.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P49296PC10		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/NL00/00586	24/08/2000	24/08/1999
International Patent Classification (IPC) or national classification and IPC A61C13/00		
Applicant NEDERLANDSE ORGANISATIE VOOR TOEGEPAST ... et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 1 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
12/01/2001	04.12.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Pypen, C Telephone No. +49 89 2399 2799

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL00/00586

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-7	as originally filed				

Claims, No.:

1-12	as received on	05/11/2001	with letter of	05/11/2001	

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☐ the claims, Nos.:
   - ☐ the drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)
see separate sheet

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 4, 12.

because:

☒ the said international application, or the said claims Nos. 12 relate to the following subject matter which does not require an international preliminary examination (*specify*):
see separate sheet

☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 4 are so unclear that no meaningful opinion could be formed (*specify*):
see separate sheet

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-3, 5-11
	No:	Claims	
Inventive step (IS)	Yes:	Claims	6
	No:	Claims	1-3, 5, 7-11
Industrial applicability (IA)	Yes:	Claims	1-11

No: Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Reference is made to the following documents:

D1: US-A-5 690 490 (BOYD GEORGE H ET AL) 25 November 1997
D2: WO 98 51747 A (INST NEUE MAT GEMEIN GMBH ;MUELLER PETER (DE); SEPEUR STEFAN (DE);) 19 November 1998
D3: US-A-5 902 441 (BREDT JAMES F ET AL) 11 May 1999
D4: US-A-5 823 778 (SCHMITT STEPHEN M ET AL) 20 October 1998
D5: WO 91 03988 A (ROHLEDER PETER (DE)) 24 September 1990

Re Item I

Basis of the report

1. The amendments filed with the letter dated 05.11.2001 introduce subject-matter which extends beyond the content of the application as filed. The amendments concerned are the following:

1.1. In the new claim 4 is claimed that in the method "the layers ... are applied to each other.." wherein "measures are taken, such that...", whereas in the initial claim 4 it was claimed that "the layers were applied onto each other, while measures are taken".
The new claim 4 is larger than the initial claim 4, since it is not necessary anymore, that the layers are applied *while* the measures are taken.

1.2. Therefore these amendments infringe with Article 19(2)/34(2)(b) PCT.

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

Claim 12 is a so-called "product-by-process" claim. Such claims are admissible only if the products themselves fulfil the requirements for patentability (T150/82, OJ 1984, 309). The subject-matter of claim 12, a dental element, is known from document D1, abstract, and therefor is not new.

Re It m V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. The subject-matter of independent claim 1 cannot be considered as involving an inventive step for the following reasons:

1.1. Document D2 discloses a method for fabricating a functional dental element by a three-dimensional printing technique, wherein successive layers of a flowable mass comprising a nanomeric material are applied onto each other, and wherein the bonding between the layers is realized by curing the nanomeric material (page 2, lines 5-12; page 4, lines 18-23; page 9, lines 25-30; page 10, line 24 - page 11, line 2).

1.2. The subject-matter of claim 1 differs in that the layers are applied using an ink-jet method.

1.3. The use of an ink-jet in a similar method for the production of dental elements is known from the document D3 (column 3, lines 60-62). Hence, since in the document D2 the flowable mass comprising a nanomeric material "can be applied by any coating-method known to the man skilled in the art" (page 9, lines 25-30), the skilled person would regard it as a normal option to include the feature of using an ink-jet in the method as described in document D2.

1.4. Therefor the subject-matter of independent claim 1 does not involve an inventive step (Art. 33(3) PCT).

2. Dependent claims 2-3, 5, 7-11 do not contain any features which, in combination with the features of any claim to which they refers, meet the requirements of the PCT in respect of inventive step, the reasons being as follows:

2.1. The additional technical features of the dependent claims 2-3 are known from the document D5 (page 3, lines 1-8).

2.2. The additional technical features of the dependent claims 5, 7, 9-10 are known from

the document D2 (page 4, lines 14-23, page 10, lines 28-31, page 2, lines 14-21).

2.3. The additional technical feature of the dependent claim 8 is known from document D4 (column 1, line 63 - column 2, line 28).

2.4. The document D3 discloses a method wherein the dental element is additionally shaped by grinding, filing, polishing, sanding, blasting or treatment with a ball bed (column 4, lines 10-11), as claimed in the dependent claim 11.

2.5. Since these additional technical features have been used for the production of dental elements in similar methods it will be obvious to the person skilled in the art to apply this features in the fabrication method.
Therefor, the subject-matter of the claims 2-3, 5, 7-11 does not involve an inventive step (Art. 33(3) PCT).

3. The subject-matter of the dependent claim 6 seems to be novel, to involve an inventive step, and to be industrially applicable (Article 33(2)-(4) PCT).

Re Item VII

Certain defects in the international application

1. The independent method claim 1 should have been worded in the two-part form, with those features known in combination from the prior art (document D2) being placed in the preamble and with the remaining features being included in the characterizing part (Rule 6.3(b)PCT, decision of the Board of Appeal T 13/84).

Re Item VIII

Certain observations on the international application

1. Claim 4 does not meet the requirements of Article 6 PCT in that the matter for which protection is sought is not clearly defined. The claim attempts to define the subject-matter in terms of the result to be achieved ("such that each layer... is removed"). The technical features necessary for achieving this result should have been added. Hence, claim 4 does not meet the requirements of Article 6 PCT.

2. The subject-matter of the initial claims 1-4, 12-13 of this application appears to be the same as the subject-matter of the initial claims 1-4, 17-18 of the application NI00/00585.

Amended Claims

1. A method for fabricating a functional dental element by a three-dimensional printing technique, wherein successive layers of a flowable mass comprising a nanomeric material are applied onto each other using an inkjet method, and wherein the bonding between the layers is realized by curing the nanomeric material.

2. A method according to claim 1, wherein the shape and dimensions of the dental element are measured in a patient while using an optical scan technique, preferably a laser technique.

3. A method according to claim 2, wherein the laser technique yields data about shape and dimensions in electronic form.

4. A method according to any one of the preceding claims, wherein measures are taken, such that each layer adheres at desired positions to a preceding layer, and excess, non-adhering material can be removed.

5. A method according to claim 4, wherein the nanomeric material consists of nanomeric, inorganic solid particles with polymerizable and/or polycondensable organic groups at their surface.

6. A method according to claim 4 or 5, wherein the layers are applied using a piezo inkjet printer.

7. A method according to claim 6, wherein curing is done using UV light.

8. A method according to claims 4-7, wherein a computer is used for controlling, on the basis of the data obtained upon measuring, a laser which cures the nanomeric material at specific, desired positions by irradiation.

9. A method according to claims 4-8, wherein the dental element is exposed to a thermal post-treatment at a temperature of 60 to 150°C.

10. A method according to claims 4-9, wherein the dental element is thermally densified at a temperature of at least 250°C.

11. A method according to any one of the preceding claims, wherein the dental element is additionally shaped by grinding, filing, polishing, sanding, blasting or treatment with a ball bed.

12. A dental element obtainable by a method according to any one of the preceding claims.

PATENT COOPERATION TREATY

1.B

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

NRF 24-4-2001

Gum

Prel. ex. 24-3-2001

To:
VEREENIGDE
Attn. PRINS, A.W.
Nieuwe Parklaan 97
2587 BN Den Haag
NETHERLANDS

Kopie in/naar

TERMIJN
0 4 DEC. 2000

Beantwoord vooril. def.

bericht gezonden aan op

Applicant's or agent's file reference
MAP P49296PC10

Date of mailing *(day/month/year)* 05/12/2000

FOR FURTHER ACTION See paragraphs 1 and 4 below

International application No.
PCT/NL 00/ 00586

International filing date *(day/month/year)* 24/08/2000

Applicant
NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUURWETEN

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority
European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer
Luis-Miguel Paredes Sanchez

Form PCT/ISA/220 (July 1998)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international pbulication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the languag of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

BNSDOCID: <XSISA220NOENP4 I >

NOTES TO FORM PCT/ISA/220 (continued)

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped),whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international appplication is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

BNSDOCID: <XSISA220NOENP4_I_>

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
P49296PC10		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/NL 00/00586	24/08/2000	24/08/1999
Applicant		
NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUURWETEN		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. _____

   [ ] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [X] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 00/00586

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61C13/00 B29C67/00 A61K6/083

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61C B29C A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 690 490 A (BOYD GEORGE H ET AL) 25 November 1997 (1997-11-25) cited in the application column 4, line 30-46 column 5, line 18-22 column 5, line 35-61 figures 4,7	1-4,12, 13
Y	---	5-11
Y	WO 98 51747 A (INST NEUE MAT GEMEIN GMBH ;MUELLER PETER (DE); SEPEUR STEFAN (DE);) 19 November 1998 (1998-11-19) cited in the application page 2, line 14-21 page 4, line 15-25 page 18, line 12-15 claims 1-3	5-11

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 November 2000	05/12/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Chabus, H

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 00/00586

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 902 441 A (BREDT JAMES F ET AL) 11 May 1999 (1999-05-11) cited in the application column 1, line 44-48 column 2, line 24-38 figure 2	1
A	---	7
X	US 5 823 778 A (SCHMITT STEPHEN M ET AL) 20 October 1998 (1998-10-20) cited in the application column 2, line 21-28	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/NL 00/00586

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5690490 A	25-11-1997	NONE	
WO 9851747 A	19-11-1998	DE 19719948 A	19-11-1998
		DE 19746885 A	24-06-1999
		AU 7654598 A	08-12-1998
		EP 0981583 A	01-03-2000
US 5902441 A	11-05-1999	DE 29724176 U	13-04-2000
		EP 0925169 A	30-06-1999
		JP 2000505737 T	16-05-2000
		WO 9809798 A	12-03-1998
US 5823778 A	20-10-1998	NONE	

REPLACED BY ART 34 AMDT

CLAIMS

1. A method for fabricating a functional dental element, wherein a three-dimensional printing technique is used.

2. A method according to claim 1, wherein the shape and dimensions of the dental element are measured in a patient while using an optical scan technique, preferably a laser technique.

3. A method according to claim 2, wherein the laser technique yields data about shape and dimensions in electronic form.

4. A method according to any one of the preceding claims, wherein layers of a suitable material are successively applied onto each other, while measures are taken, such that each layer adheres at desired positions to a preceding layer, and excess, non-adhering material is removed.

5. A method according to claim 4, wherein the suitable material is a nanomeric material and wherein the bonding between the layers is realized by curing the nanomeric material.

6. A method according to claim 5, wherein the nanomeric material consists of nanomeric, inorganic solid particles with polymerizable and/or polycondensable organic groups at their surface.

7. A method according to claim 5 or 6, wherein the layers are applied using a piezo inkjet head.

8. A method according to claim 7, wherein curing is done using UV light.

9. A method according to claims 5-8, wherein a computer is used for controlling, on the basis of the data obtained upon measuring, a laser which cures the nanomeric material at specific, desired positions by irradiation.

10. A method according to claims 5-9, wherein the dental element is exposed to a thermal post-treatment at a temperature of 60 to 150°C.

11. A method according to claims 5-10, wherein the dental element is thermally densified at a temperature of at least 250°C.

12. A method according to any one of the preceding claims, wherein the dental element is additionally shaped by grinding, filing, polishing, sanding, blasting or treatment with a ball bed.

13. A dental element obtainable by a method according to any one of the preceding claims.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P49296PC10		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/NL00/00586	24/08/2000	24/08/1999
International Patent Classification (IPC) or national classification and IPC A61C13/00		
Applicant NEDERLANDSE ORGANISATIE VOOR TOEGEPAST ... et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 1 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
12/01/2001	04.12.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Pypen, C Telephone No. +49 89 2399 2799

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL00/00586

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-7	as originally filed				
Claims, No.:					
1-12	as received on	05/11/2001	with letter of	05/11/2001	

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☐ the claims, Nos.:
   - ☐ th drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go b yond the disclosure as filed (Rul 70.2(c)):

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL00/00586

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)
see separate sheet

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 4, 12.

because:

☒ the said international application, or the said claims Nos. 12 relate to the following subject matter which does not require an international preliminary examination (*specify*):
see separate sheet

☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 4 are so unclear that no meaningful opinion could be formed (*specify*):
see separate sheet

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 1-3, 5-11
	No:	Claims
Inventive step (IS)	Yes:	Claims 6
	No:	Claims 1-3, 5, 7-11
Industrial applicability (IA)	Yes:	Claims 1-11

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL00/00586

No: Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

INTERNATIONAL PRELIMINARY EXAMINATION REPORT - SEPARATE SHEET

International application No. PCT/NL00/00586

Reference is made to the following documents:

D1: US-A-5 690 490 (BOYD GEORGE H ET AL) 25 November 1997
D2: WO 98 51747 A (INST NEUE MAT GEMEIN GMBH ;MUELLER PETER (DE); SEPEUR STEFAN (DE);) 19 November 1998
D3: US-A-5 902 441 (BREDT JAMES F ET AL) 11 May 1999
D4: US-A-5 823 778 (SCHMITT STEPHEN M ET AL) 20 October 1998
D5: WO 91 03988 A (ROHLEDER PETER (DE)) 24 September 1990

Re Item I

Basis of the report

1. The amendments filed with the letter dated 05.11.2001 introduce subject-matter which extends beyond the content of the application as filed. The amendments concerned are the following:

1.1. In the new claim 4 is claimed that in the method "the layers ... are applied to each other.." wherein "measures are taken, such that...", whereas in the initial claim 4 it was claimed that "the layers were applied onto each other, while measures are taken".
The new claim 4 is larger than the initial claim 4, since it is not necessary anymore, that the layers are applied *while* the measures are taken.

1.2. Therefore these amendments infringe with Article 19(2)/34(2)(b) PCT.

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

Claim 12 is a so-called "product-by-process" claim. Such claims are admissible only if the products themselves fulfil the requirements for patentability (T150/82, OJ 1984, 309). The subject-matter of claim 12, a dental element, is known from document D1, abstract, and therefor is not new.

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. The subject-matter of independent claim 1 cannot be considered as involving an inventive step for the following reasons:

1.1. Document D2 discloses a method for fabricating a functional dental element by a three-dimensional printing technique, wherein successive layers of a flowable mass comprising a nanomeric material are applied onto each other, and wherein the bonding between the layers is realized by curing the nanomeric material (page 2, lines 5-12; page 4, lines 18-23; page 9, lines 25-30; page 10, line 24 - page 11, line 2).

1.2. The subject-matter of claim 1 differs in that the layers are applied using an ink-jet method.

1.3. The use of an ink-jet in a similar method for the production of dental elements is known from the document D3 (column 3, lines 60-62). Hence, since in the document D2 the flowable mass comprising a nanomeric material "can be applied by any coating-method known to the man skilled in the art" (page 9, lines 25-30), the skilled person would regard it as a normal option to include the feature of using an ink-jet in the method as described in document D2.

1.4. Therefor the subject-matter of independent claim 1 does not involve an inventive step (Art. 33(3) PCT).

2. Dependent claims 2-3, 5, 7-11 do not contain any features which, in combination with the features of any claim to which they refers, meet the requirements of the PCT in respect of inventive step, the reasons being as follows:

2.1. The additional technical features of the dependent claims 2-3 are known from the document D5 (page 3, lines 1-8).

2.2. The additional technical features of the dependent claims 5, 7, 9-10 are known from

the document D2 (page 4, lines 14-23, page 10, lines 28-31, page 2, lines 14-21).

2.3. The additional technical feature of the dependent claim 8 is known from document D4 (column 1, line 63 - column 2, line 28).

2.4. The document D3 discloses a method wherein the dental element is additionally shaped by grinding, filing, polishing, sanding, blasting or treatment with a ball bed (column 4, lines 10-11), as claimed in the dependent claim 11.

2.5. Since these additional technical features have been used for the production of dental elements in similar methods it will be obvious to the person skilled in the art to apply this features in the fabrication method.
Therefor, the subject-matter of the claims 2-3, 5, 7-11 does not involve an inventive step (Art. 33(3) PCT).

3. The subject-matter of the dependent claim 6 seems to be novel, to involve an inventive step, and to be industrially applicable (Article 33(2)-(4) PCT).

Re Item VII

Certain defects in the international application

1. The independent method claim 1 should have been worded in the two-part form, with those features known in combination from the prior art (document D2) being placed in the preamble and with the remaining features being included in the characterizing part (Rule 6.3(b)PCT, decision of the Board of Appeal T 13/84).

Re Item VIII

Certain observations on the international application

1. Claim 4 does not meet the requirements of Article 6 PCT in that the matter for which protection is sought is not clearly defined. The claim attempts to define the subject-matter in terms of the result to be achieved ("such that each layer... is removed"). The technical features necessary for achieving this result should have been added. Hence, claim 4 do s not meet the r quirements of Article 6 PCT.

2. The subject-matter of the initial claims 1-4, 12-13 of this application appears to be the same as the subject-matter of the initial claims 1-4, 17-18 of the application NI00/00585.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

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PCT

(10) International Publication Number
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(25) Filing Language: Dutch

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1012897 24 August 1999 (24.08.1999) NL

(71) Applicant *(for all designated States except US)*: **NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUURWETENSCHAPPELIJK ONDERZOEK TNO** [NL/NL]; Schoemakerstraat 97, NL-2628 VK Delft (NL).

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(75) Inventor/Applicant *(for US only)*: **FEENSTRA, Frits, Kornelis** [NL/NL]; Rosa Manuslaan 48, NL-2642 DR Pijnacker (NL).

(74) Agent: **PRINS, A., W.**; Vereenigde, Nieuwe Parklaan 97, NL-2587 BN The Hague (NL).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 01/13815 A1

(54) Title: METHOD FOR MAKING A DENTAL ELEMENT

(57) Abstract: The present invention relates to a method for fabricating a functional dental element, such as a crown. According to the invention, use is made of a three-dimensional printing technique. The major advantages of the invention are that no mold is needed anymore, which entails a considerable saving of costs, that a great accuracy is achieved, and that the element can be made of different materials.

Title: Method for making a dental element.

The invention relates to a method for making a functional dental element and to a dental element obtainable by such method.

Dental elements, such as crowns, are used in clinical practice mainly for replacing or correcting dental structures. This can involve partly or wholly lost teeth or molars. To date, materials for such elements have been examined in particular for technological/physical and chemical properties. Currently, in addition, the biological aspect plays an increasing role.

Dental elements can be fabricated from different materials. Examples include polymers, metals, composites, combinations of porcelain and metal, porcelain and other ceramic materials. Glass and ceramic materials form an ideal group of materials for dental elements, because they are hard, have a high wear resistance, are chemically inert in many media (biocompatibility), and can be simply formed into an aesthetic dental element. A broad application of these materials, however, is impeded by the inherent brittleness which is often the result of limitations in the fabricating process and of the material choice. Recent developments have led to different ceramic systems, such as sintered ceramic, glass-infiltrated ceramic and glass-ceramic of various compositions, which are less brittle.

The fabrication of dental elements in practice is a complex and time consuming affair. The products involved are fabricated on an individual basis since the exact form of the element is different for every tooth or molar in every individual. Conventional techniques that have been used often utilize a mold. Since this mold can typically be used only once, it will be clear that these techniques are very costly.

In the past, techniques have been proposed which supposedly enable simplification of the fabricating process of dental elements. Thus,

Abe et al., in Int. J. Japan Soc. Prec. Eng., vol. 30, no. 3, 1996, pp. 278-279, have proposed to carry out a selective laser sintering (SLS) with titanium. This technique, however, often gives rise to shrinkage. Also, microcracks may be formed, which renders the technique unsuitable for the fabrication of functional dental elements. In European patent application 0 311 214 it has been proposed to make a crown by milling. Milling does not provide the possibility of making colored elements. Moreover, the choice of suitable materials that can be processed by milling is limited. As noted, ceramic materials form an ideal group of materials for fabricating dental elements, because they are hard, highly wear-resistant and inert under many conditions.

U.S. Patent 5,690,490 describes a method for the fabrication of a concept model for a dental element by so-called pinhead molding. The method concerns the use of a kind of matrix printing technique, whereby material is sprayed on. The printer is controlled with a CAD/CAM program. The data which this program utilizes have been obtained from a laser scan of the tooth or the molar to be replaced.

In U.S. Patent 5,823,778, a method is described for fabricating a dental element whereby an impression of the teeth of a patient is obtained, which is subsequently used as a mold to make a copy of a dental element. This element is broken down in layers and each layer is scanned to obtain a three-dimensional computer model of the dental element.

One object of the present invention is to provide a technique whereby functional dental elements can be fabricated in a flexible and efficient manner. Another object is for the technique not to utilize a mold, and to enable making dental elements of polymeric, metallic or ceramic material, or of combinations thereof.

Surprisingly, it has presently been found that the stated objects are achieved by fabricating a dental element utilizing a three-dimensional printing technique.

Three-dimensional printing techniques are known per se, and described inter alia in European patent application 0 431 924, U.S. Patent 5,902,441 and international patent applications 94/19112, 97/26302 and 98/51747. For a description of the details of the technique, reference is made to the documents mentioned, which are therefore to be understood to be inserted herein.

The method according to the invention is in principle suitable for fabricating all types of dental elements. Examples include crowns (front and lateral teeth), inlays, overlays, onlays, partial crowns, fixations and veneers.

Preferably, in a patient in whom a dental element is to be replaced/placed, it is first accurately measured what shape the element is to have. Often, if possible, the starting point will be the shape of the tooth or molar, or the portion thereof that is to be replaced. It is preferred that measurement can take place in a manner which causes the patient as little inconvenience as possible. Particularly suitable techniques for measuring the shape for the dental element make use of optical scan techniques, in particular lasers. In electronic form, data about the desired shape and dimensions are thereby obtained, which can be directly visualized in a computer. The electronic data about the shape and dimensions of the dental element are preferably used by a computer to control the execution of the three-dimensional printing technique. Another suitable method for measuring is by the CEREC-technique, Sirona Dental Systems GmbH, Bensheim, Germany.

In the three-dimensional printing technique, a suitable material is applied successively in layers, while specific steps are taken to ensure that each layer adheres to the preceding layer only at particular desired points. These specific steps are determined by the desired shape of the dental element and preferably controlled by the above-mentioned electronic data.

According to the invention, in the specific steps mentioned, use is made of a selective curing. The dental element is built up from layers, this

time of a specific curable material, whereby each layer adheres to the desired positions of the preceding layer by allowing the material to cure only at the desired positions. The non-cured material will not adhere to the preceding layer and can be readily removed.

The curable material is preferably a nanomeric material, as described in WO-A-98/51747. Such a material consists of nanomeric, inorganic solid particles having polymerizable and/or polycondensable organic groups at their surface. It is preferred that this material is applied in the form of a flowable mass, for instance a dispersion of the material in water, an organic solvent, or a monomeric solution. In this context, a monomer solution is understood to mean a mixture of UV photopolymerizable monomers and a solvent suitable therefor. Suitable examples of monomers contain epoxy and/or acryl groups. As solvent, for instance styrene can be used. Nanomeric inorganic solid particles are understood to be particles having an average particle size (diameter) of less than 200 nm, preferably less than 100 nm. Found to be particularly suitable are particles having an average diameter of 5-50 nm.

The nanomeric, inorganic solid particles can consist of different materials, but it is preferred that they comprise a metal or metal compound. Examples of suitable materials are inter alia ZnO, CdO, SiO_2, TiO_2, ZrO_2, CeO_2, SnO_2, Al_2O_3, In_2O_3, La_2O_3, Fe_2O_3, Cu_2O, Ta_2O_5, Nb_2O_5, V_2O_5, MoO_3, WO_3, CdS, ZnS, PbS, Ag_2S, GaSe, CdSe, ZnSe, ZnTe, CdTe, AgCl, AgBr, AgI, CuCl, CuBr, CdI_2, PbI_2, CdC_2, SiC, AlAs, GaAs, GeAs, InSb, BN, AlN, Si_3N_4, Ti_3N_4, GaP, InP, Zn_3P_2, Cd_3P_2, phosphates, silicates, zirconates, aluminates, stannates and corresponding mixed oxides (as with a perovskite structure, e.g. $BaTiO_3$ and $PbTiO_3$). Preferred are materials comprising oxides, sulfides, selenides or tellurides of metals, or mixtures thereof. Preferred in particular are nanomeric particles of SiO_2, TiO_2, ZrO_2, ZnO, Ta_2O_5, SnO_2 and Al_2O_3 (in all forms, in particular as boehmite, AlO(OH)) and mixtures thereof.

The polymerizable and/or polycondensable organic groups can preferably form polymers under the influence of irradiation with a laser. This polymerization can proceed via any suitable mechanism. Preferably, the polymerization is photochemical or thermal. If desired, an initiator can be added to the flowable mass, being the form in which the nanomeric material is processed. (Meth)acryl, allyl, vinyl, epoxy, hydroxy, carboxy and amino groups are preferred, a particular preference being expressed for (meth)acryl and epoxy groups.

According to the invention, it is preferred that the polymerizable and/or polycondensable organic groups have a relatively low molecular weight. Preferably, their molecular weight is below 500, more preferably below 200.

The preparation of nanomeric, inorganic solid particles with polymerizable and/or polycondensable organic groups at their surface is known per se and described, inter alia, in international patent application 98/51747.

As mentioned, the nanomeric material is applied in the form of a flowable mass in layers. The flowable mass can be formed by forming a dispersion of the nanomeric material in water or any other suitable solvent. Here, it is preferred to work with a concentration between 25 and 60% by weight of nanomeric material, based on the weight of the dispersion. Applying the layers can be done in any suitable manner, such as spraying, streaking and the like. The thickness of the layers in these cases is preferably between 0.01 and 0.1 mm.

Between the application of the successive different layers, each layer is cured at specific, desired positions. The electronic data which have been obtained by measuring the shape and dimensions of the desired dental element in a patient can be used to control a laser which accurately irradiates each layer at the desired positions, so that the desired curing

occurs and the layer adheres to a preceding layer at the desired points. Material which has not cured can be easily removed.

This method can also, as a special feature, process UV curing nanomer-containing resins which have been colored (with inorganic colorant), which enables the fabrication of colored functional dental elements. This process also provides the possibility of illuminating, and thereby curing, the surface in one go using a UV lamp, which proceeds faster than local curing with a laser. The process utilizes a number of nozzles equal to a power of 2, preferably between 100 and 10,000 nozzles, in particular 1536 nozzles. According to an alternative embodiment, the flowable mass can be applied in layers using an inkjet method. Preferably, use is made here of a piezo inkjet printer with a head of preferably 1536 nozzles. In this case, the thickness of the layers is preferably between 10 and 40 μm.

In particular cases, it has been found to be advantageous to subject the dental element to a thermal post-treatment, so that a complete curing is achieved. Thus, preferably, the dental element is briefly heated to a temperature between 60 and 150°C, more preferably between 80 and 130°C.

Instead thereof, or supplemental thereto, preferably a thermal densification is accomplished. To that end, the dental element is heated to a temperature of at least 250°C, preferably at least 400°C and more preferably at least 500°C. This treatment contributes to the dental element obtaining particularly favorable properties.

When by one of the procedures described above the dental element has been formed, it may happen that it still needs to be additionally shaped to some extent. As has already been indicated, it is an advantage of the invention that it enables work to be done very accurately. Additional shaping will therefore be less laborious than in the techniques used heretofore. Ways in which additional shaping can be carried out include inter alia grinding, filing, polishing, sanding, blasting or treatment with a

ball bed, depending on the selected material of the dental element. After this, typically a surface treatment/sealing is desirable.

The invention will presently be elucidated in and by the following examples.

Example 1

ZrO_2 particles of an average diameter of 10 nm are dispersed in isopropanol with stirring and ultrasound treatment. To modify the surface of the particles, 3.2 wt.%, based on the ZrO_2 content, of 3-methacryloxypropyltrimethoxysilane (MPTS) is added. The dispersion is stirred at 50°C for 3 hours to obtain a silanized surface.

Subsequently, 3.2 wt.%, based on the ZrO_2 content, of tetraethyleneglycoldimethacrylate (TEGDMA) is added and stirring is done at 20°C for 15 minutes. Three mole % of Irgacure® 184 is added per mole of double bond. Then the solvent is partly removed under vacuum.

Of the material thus obtained, the curing depth (Cd) is determined. An amount of the material is brought into a cylindrical form, which form transmits UV radiation. A UV dryer having a power of 400 mW/cm^2 is used for curing. The material is exposed to radiation for a period between 1 and 2 minutes (up to 20 UV radiation cycles). The power used is varied. The results of this tunnel curing test are programmed into an SLA machine (SLA250 of the firm 3D Systems Inc., Valencia CA USA).

Of the above-described dispersion, a layer of a thickness of 0.05 mm is applied to a building surface (20x20 cm) using a doctor blade. This layer is selectively irradiated with a HeCd laser, so that at specific points a curing reaction is initiated. This procedure is repeated until an element of the desired shape and dimension has been obtained. Finally, the element is exposed to a heat treatment at 120°C for 15 minutes.

CLAIMS

1. A method for fabricating a functional dental element, wherein a three-dimensional printing technique is used.

2. A method according to claim 1, wherein the shape and dimensions of the dental element are measured in a patient while using an optical scan technique, preferably a laser technique.

3. A method according to claim 2, wherein the laser technique yields data about shape and dimensions in electronic form.

4. A method according to any one of the preceding claims, wherein layers of a suitable material are successively applied onto each other, while measures are taken, such that each layer adheres at desired positions to a preceding layer, and excess, non-adhering material is removed.

5. A method according to claim 4, wherein the suitable material is a nanomeric material and wherein the bonding between the layers is realized by curing the nanomeric material.

6. A method according to claim 5, wherein the nanomeric material consists of nanomeric, inorganic solid particles with polymerizable and/or polycondensable organic groups at their surface.

7. A method according to claim 5 or 6, wherein the layers are applied using a piezo inkjet head.

8. A method according to claim 7, wherein curing is done using UV light.

9. A method according to claims 5-8, wherein a computer is used for controlling, on the basis of the data obtained upon measuring, a laser which cures the nanomeric material at specific, desired positions by irradiation.

10. A method according to claims 5-9, wherein the dental element is exposed to a thermal post-treatment at a temperature of 60 to 150°C.

11. A method according to claims 5-10, wherein the dental element is thermally densified at a temperature of at least 250°C.

12. A method according to any one of the preceding claims, wherein the dental element is additionally shaped by grinding, filing, polishing, sanding, blasting or treatment with a ball bed.

13. A dental element obtainable by a method according to any one of the preceding claims.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

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Applicant
NEDERLANDSE ORGANISATIE VOOR TOEGEPAST ... et al

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

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